WO 2004/003256 PCT/US2003/016240

CLAIMS:

1. A method for anisotropically etching a Cu-containing layer comprising the steps of:

providing a Cu-containing layer overlying a substrate;

introducing a directional beam of neutral oxygen atoms having high kinetic energy;

oxidizing the Cu-containing layer by exposure to the beam of oxygen atoms;

introducing a reagent capable of forming volatile etch products when reacted with the oxidized Cu-containing layer;

removing the etch products from the Cu-containing layer.

- 2. The method according to claim 1, wherein the reagent comprises a β -diketone gas.
- 3. The method according to claim 2, wherein the β -diketone gas comprises at least one of acacH, tfacH, and hfacH.
- 4. The method according to claim 1, further comprising introducing an inert gas.
- 5. The method according to claim 4, wherein the inert gas comprises at least one of argon, helium, xenon, and nitrogen.
- 6. The method according to claim 1, wherein the substrate is maintained at a temperature below 200°C.
- 7. The method according to claim 1, wherein the substrate is maintained at a temperature below 150°C.

WO 2004/003256 PCT/US2003/016240

8. The method according to claim 1, wherein the substrate is maintained at a temperature below 100°C.

- 9. The method according to claim 1, wherein the neutral oxygen atoms have kinetic energy between 10eV and 1eV.
- 10. The method according to claim 1, wherein the neutral oxygen atoms have kinetic energy between 100eV and 10eV.
- 11. The method according to claim 1, wherein the neutral oxygen atoms have kinetic energy in excess of 100eV.
- A processing system for etching Cu-containing layers comprising:
 a process chamber;
- a source of a directional beam of neutral oxygen atoms having high kinetic energies;
- a gas injection system configured to inject a process gas into the process chamber, wherein the process gas comprises a reactant gas;
- a substrate holder, the substrate holder exposes a substrate comprising a Cu-containing layer to the source of neutral oxygen atoms and the reactant gas; and
 - a controller that controls the processing system.
- 13. The system according to claim 12, wherein the source of a directional beam of neutral oxygen atoms comprises a RF source.
- 14. The system according to claim 12, wherein the source of a directional beam of neutral oxygen atoms comprises a laser-induced discharge source.
- 15. The system according to claim 12, wherein the neutral oxygen atoms have kinetic energies between 100eV and 10eV.

WO 2004/003256 PCT/US2003/016240

16. The system according to claim 12, wherein the neutral oxygen atoms have kinetic energies between 10eV and 1eV.

- 17. The system according to claim 1, wherein the neutral oxygen atoms have kinetic energies in excess of 100eV.
- 18. The system according to claim 12, wherein the reactant comprises a β -diketone gas.
- 19. The system according to claim 12, wherein the β -diketone gas comprises at least one of acacH, tfacH, and hfacH.
- 20. The method according to claim 12, wherein the process gas further comprises an inert gas.
- 21. The system according to claim 20, wherein the inert gas comprises at least one of argon, helium, xenon, and nitrogen.